APPENDIX D

INSTRUCTIONS AND FORMS

D.1 Estimated dispersant dosages based on average oil thickness and dispersant-to-oil ratios

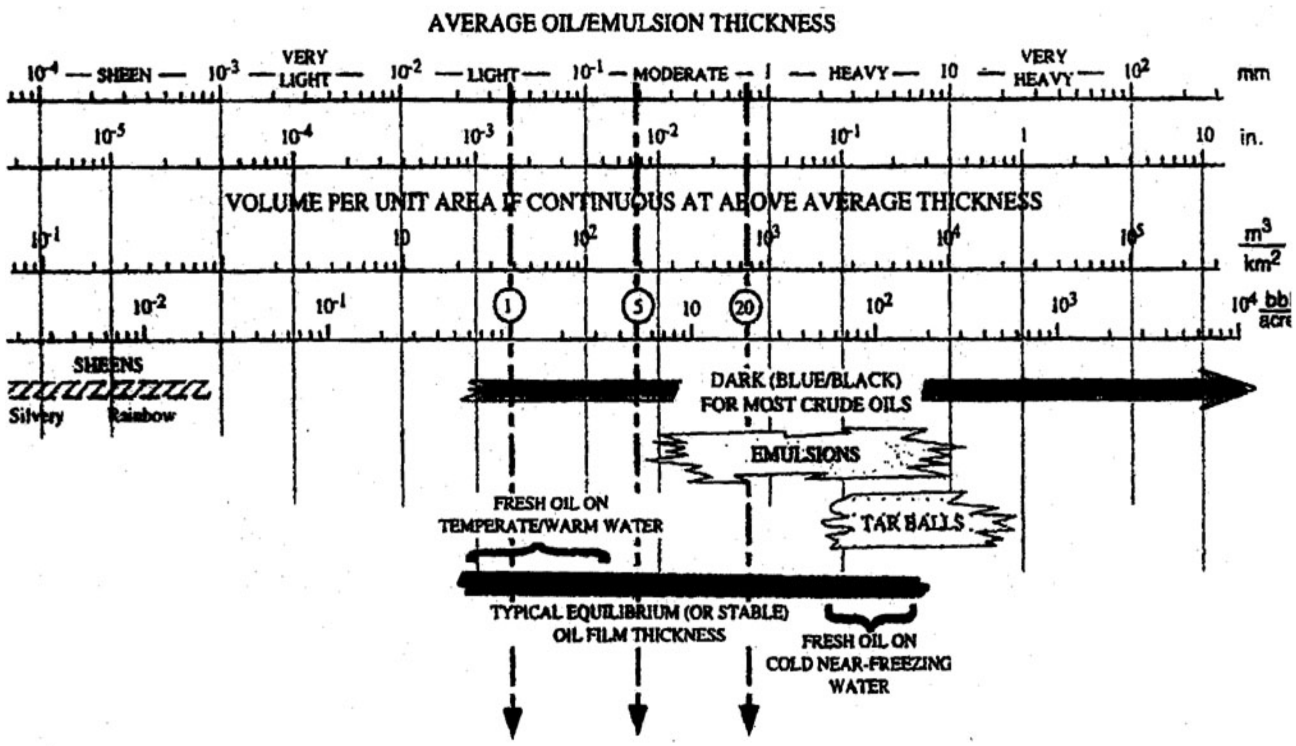
Average oil thickness (inches) (mm)	**Relative thickness**	**Oil concentration (volume of oil/unit area)**	**Dispersant-to-oil ratio (DOR)** 1:1*	1:5 *	1:10	1:20	1:50	1:100
.0004 in (0.01 mm)	Very light to light	Gallons/acre	10.7	2.14	1.1	0.5	0.2	0.1
		Gallons/km^2	2642	528.4	264.2	132.1	52.8	26.4
		Liters/hectare	100	20	10	5	2	1
.001 in (0.02 mm)	Light	Gallons/acre	21.4	4.3	2.1	1.1	0.4	0.2
		Gallons/km^2	5284	1057	528.4	264.2	105.7	52.8
		Liters/hectare	200	40	20	10	4	2
.002 in (0.05 mm)	Light	Gallons/acre	53.5	10.7	5.4	2.7	1.1	0.5
		Gallons/km^2	13210	2642	1321	660.5	264.2	132.1
		Liters/hectare	500	100	50	25	10	5
.004 in (0.1 mm)	Light to moderate	Gallons/acre	107	21.4	10.7	**5.4 ****	2.1	1.1
		Gallons/km^2	26420	5284	2642	1321	528.4	264.2
		Liters/hectare	1000	200	100	50	20	10
.019 in (0.5 mm)	Moderate	Gallons/acre	535	107	53.5	26.8	10.7	5.4
		Gallons/km^2	132100	26420	13210	6605	2642	1321
		Liters/hectare	5000	1000	500	250	100	50
.04 in (1.0 mm)	Moderate to heavy	Gallons/acre	1070	214	107	53.5	21.4	10.7
		Gallons/km^2	264200	52840	26420	13210	5284	2642
		Liters/hectare	10000	2000	1000	500	200	100
.08 in (2.0 mm)	Heavy	Gallons/acre	2140	428	214	107	42.8	21.4
		Gallons/km^2	528400	105680	52840	26420	10568	5284
		Liters/hectare	20000	4000	2000	1000	400	200
0.12 in (3.0 mm)	Heavy	Gallons/acre	3210	642	321	160.5	64.2	32.1
		Gallons/km^2	792600	158520	79260	39630	15852	7926
		Liters/hectare	30000	6000	3000	1500	600	300

* The general formula to use is : 10^4 x area (hectare) x thickness (mm) = volume (liters). Convert liters/hectare to gallons/acre by multiplying by .107, and to gallons/km^2 by multiplying by 26.42. For example, for the 1:1 ratio at 0.01mm thickness: 10^4 (=10,000) x .01mm = 100 liters/hectare. 100 liters/hectare x .107 = 10.7 gallons/acre.
100 liters/hectare x 26.42 = 2642 gallons/km^2. To develop the other dilution ratios, multiply the 1:1 numbers by the appropriate fraction (1:5 ratio, multiply by 1/5 or .2; 1:10 ratio, multiply by 1/10 or .1; 1:20 ratio multiply by 1/20 or .05; 1:50 ratio multiply by 1/50 or .02; 1:100 ratio, multiply by 1/100 or .01). Generate other ratios, for another oil thickness or DOR, in similar fashion. To convert to other units, use the conversion factors in Appendix K.

** This is how the generally-applied 5 gallons/acre number has been generated, assuming a light to moderate oil thickness and a DOR of 1:20. However, the table also makes it apparent that many other ratios may be appropriate depending on the volume or thickness of the spilled oil. How the oil behaves in the environment once it is spilled, and the dispersant application platform chosen, will also add a number of variables the FOSC will need to consider. Please see Discussion Note 9.1 for more information on slick thickness, oil volume, and dosage rate, as well as the the figures in Appendices D.2 and D.3.

D.2 Representative oil concentrations and corresponding average thicknesses

The circled numbers on the vertical lines in the figure above refer to 1, 5 and 20 barrels/acre as representative values for days 1, 2 and 3 following a significant crude oil spill.

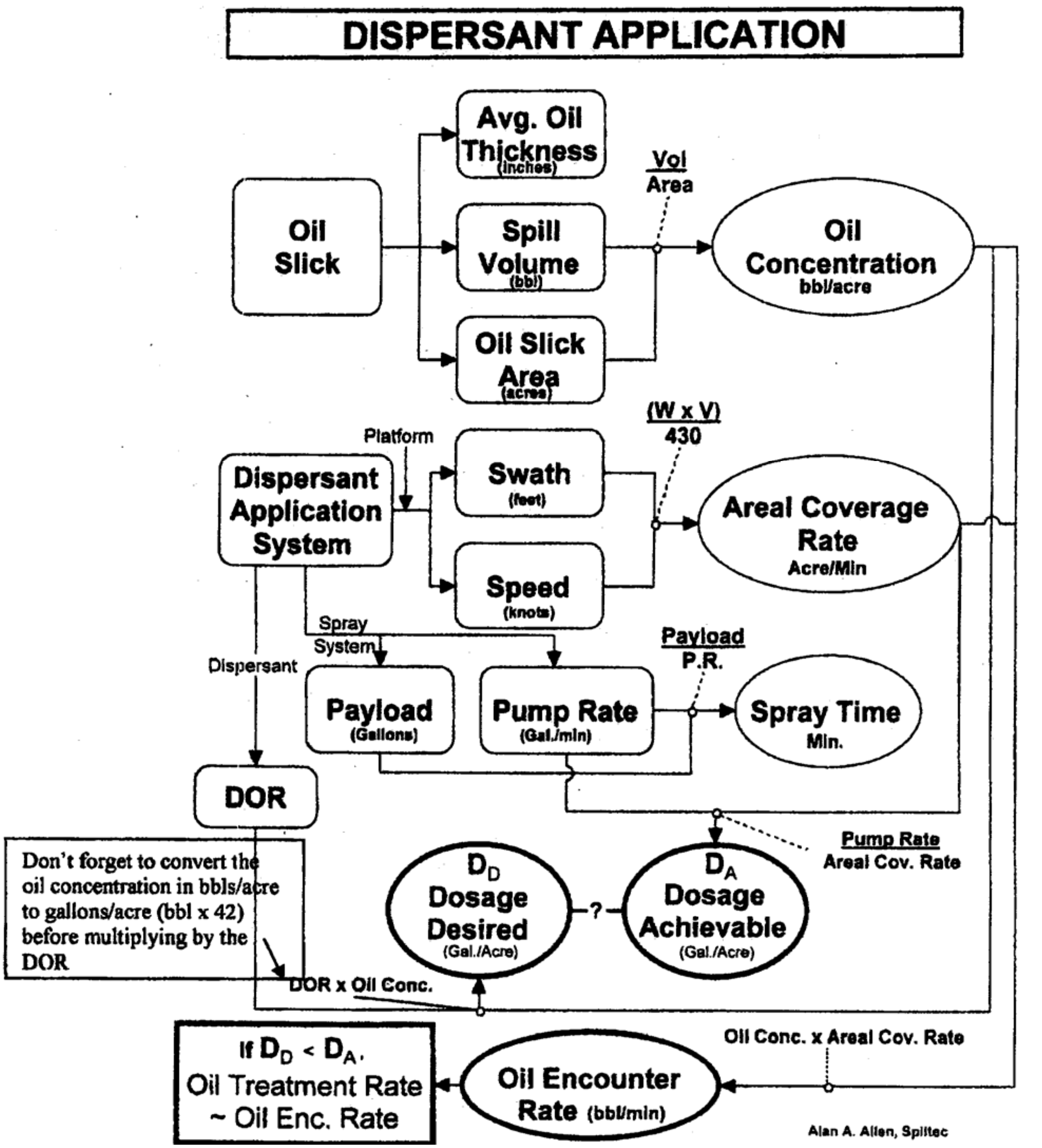


	DAY 3	DAY 2	DAY 1
Estimated Volume/Unit Area (bbl/acre)	1	5	20
Average Oil Thickness (inches)	0.0016	0.0077	0.031
Average Oil Thickness (millimeters)	0.039	0.197	0.79

REPRESENTATIVE OIL CONCENTRATIONS & CORRESPONDING AVERAGE THICKNESS
(For Planning Purposes)

From Alan A. Allen (Spiltec), 2003 personal communication

D.3 **Oil slick characteristics and DOR as they apply to the dispersant application system**



D.4 Dispersant Application Summary Form

Incident name: ______________________________ Report number: __________

This report made by: ___________________________ Organization/agency: ____________________ Date: __________ Time: _______

Application parameters:

General location of application: __________________________________

Size of target area: __________________________________ (m^2/km^2/acres)
Circle one

Volume of oil targeted: __________________________________ (gal/bbl)
(from Dispersant Pre-Approval Assessment Form) Circle one

Dispersant: oil ratio used: __________________________________

Volume of dispersant required: __________________________________ (gal/bbl)
(calculate or use Appendix D.1) Circle one

Diagram of application. Include scale, north arrow, location of oil, flight path and application location. Partition this box if multiple passes are expected so that each pass may be sketched.

Application platform:

Aircraft/Boat/Other: ___________________________

Type: ___________________________

Capacity: ___________________________

Pump rate: ___________________________

Swath width: ___________________________

Application speed: ___________________________

Application capacity:

Distance to slick: ___________________________

Base to spill return time: ________________________

Applications per hour: ________________________

Coverage per hour: ________________________

Application details:

Pass number:	Start time	Finish time	Total dispersant applied
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

In part from Cawthron, 2000

D.5 Monitoring dispersant effectiveness

Information in this section is based on the SMART (Special Monitoring of Advanced Response Technologies) Guidelines – a joint project of the U.S. Coast Guard, National Oceanic and Atmospheric Administration (NOAA), US Environmental Protection Agency (EPA), the Centers for Disease Control and Prevention and the Minerals Management Service. Additional information is from the NOAA HAZMAT Report 96-7.

- It is essential to monitor the effectiveness of dispersant applications on oil dispersion.
- It is desirable to monitor the fate of oil, and to assess the impact of dispersed oil on the environment.
- Monitoring intensity should reflect spill size and prevailing conditions, as well as the potential effects of the spill, and logistical and physical constraints. Monitoring intensity should increase with spill size as follows:

		Water column monitoring and sample collection	
Spill size	**Visual monitoring**	1 m depth	multiple depths
Small	✔		
Medium	✔	✔	
Large	✔	✔	✔

- Visual observation of dispersant effectiveness is the minimum acceptable level of monitoring.
- Termination of dispersant operations should, wherever possible, be based on real-time on-site water column monitoring results from at least one depth.
- Monitoring at multiple depths (either with real-time data or samples collected for later analysis) will provide the best information on dispersant effectiveness and the fate of dispersed oil.

Mobilizing monitoring resources

- It is imperative that monitoring teams and technical advisors are notified of possible dispersant use, and are mobilized as soon as possible (see **Box 1a).**
- Dedicated monitoring staff should be appointed and should not be expected to perform other operational functions.

Visual observation

- Visual observation from aircraft is the most reliable technique for detecting and mapping oil distribution.
- General aerial observation objectives include mapping the distribution and appearance of the oil, verifying the modeled forecast of oil movement, providing responders with an overview of the incident, and directing cleanup operations.
- Observations should be made using the General Observation Guidelines (Appendix D.4), Dispersant Observation Checklist (Appendix D.5) and Dispersant Observation Report Form (Appendix D.6).
- Observations should be photographed and/or videotaped for comparison and documentation.
- Oil close to the coastline is best viewed from a helicopter, ideally with a door or window removed allowing the observer to look straight down on the oil.
- For oil further offshore, multi-engine aircraft provide a longer range, higher speeds and wider margin of safety.
- As a minimum, the aircraft should have space for two observers (excluding the pilot), visibility from both sides, pilot-observer communications, and sufficient navigational aids to follow the proposed flight path.
- Prior to take-off, the observer should be aware of aircraft safety procedures, be familiar with the general spill area, have appropriate maps or nautical charts to record spill details, and know the environmental conditions likely to be encountered.
- Visibility, surface wind speed and direction, and sea state are all important for predicting oil movement and interpreting visual observations. Poor viewing conditions (*e.g.*, fog, rain, or overwashing in rough seas) can prevent observers from seeing the entire spill. Strong winds could indicate emulsification rates may be more rapid than anticipated.
- Advanced sensing instruments (*e.g.*, infrared thermal imaging, side-looking airborne radar, laser fluorescence, microwave radiometer, infrared-ultraviolet line scanner, LANDSAT satellite systems) can provide a high

Appendix D.5 continued

degree of sensitivity in determining dispersant effectiveness. Problems associated with each of these systems preclude their exclusive use during oil spills. Visual observations cannot always confirm that the oil is dispersed, and physical sampling of water beneath the slick may also be required.

Water column fluorometry and water samples

- Dispersant effectiveness can be confirmed in real-time by monitoring hydrocarbons in the water column using fluorometry.
- For medium and large spills, on-site monitoring is the preferred method for determining whether there is a significant difference between natural and chemical dispersion, and for deciding when dispersant operations should cease. It also provides the best means for determining the volume of chemically dispersed oil.
- Samples should ideally be collected at multiple depths from:
  - Water free of oil contamination (reference or control sites)
  - Water beneath the oil spill before dispersant application (pre-treatment)
  - Water beneath the oil spill after dispersant application (post-treatment)
- The time of sampling, instrument readings, relevant observations at selected time intervals and the exact position of each reading (preferably using Global Position System) must be recorded. Documentation of fluorometer calibration and verified instrument response should also be available.
- The sampling regime will depend on the availability of monitoring resources, the spill size and the logistical constraints of the response. At a minimum, sufficient samples are needed to characterize pre- and post-treatment differences relative to reference sites.
- As fluorometry measures natural fluorescence and not just oil, water samples should also be collected to allow fluorometry results to be related to measured oil concentrations. Fluorometry measures should be made using a continuous flow fluorometer. Water samples should be collected at the outlet port of the flow-trhough water duct, past the fluorometer cell. Water samples should be kept in a cool dark place prior to laboratory analysis.

Fate of dispersed oil

- Monitoring the track of the dispersed oil plume at several depths allows the dilution rate for the dispersed oil to be assessed, and the determination of the rate that hydrocarbon levels in the water column return to background levels.
- Trajectory models should be used where available to assist in tracking the plume. Dye markers can also be used.
- Oil fate monitoring requires:
  - Simultaneous monitoring from a single vessel using independent set-ups from at least two depths.
  - Collection of water samples to validate the fluorometer readings.
  - Wherever possible, measurement of water quality parameters (*e.g.*, temperature, conductivity, dissolved oxygen, pH, turbidity) to help explain the behavior of the dispersed oil.

Using and interpreting monitoring results

- Fluorometry readings will vary widely, reflecting the patchiness and inconsistency of the dispersed oil plume.
- Real-time data are essential if monitoring results are being used to guide dispersant operations and to determine when a response is no longer effective.
- An increase in the fluorometer signal trend beneath chemically dispersed oil of five times or greater than that of readings beneath untreated oil and reference sites is a good indication of dispersion occurring.
- It is important that actual oil concentrations are also measured so that the rate of natural dispersion can be compared to the rate of chemically enhanced dispersion, to determine the actual effect of dispersant use.

From Cawthron, 2000

D.6 General observation guidelines

- Wherever possible, use observers trained and experienced in identifying and quantifying oil floating on the sea;
- Use standard reporting terms (see below) and common guidelines to maintain consistency among observers.

STANDARD TERMS TO DESCRIBE OIL FLOATING ON THE WATER		
1	**Light sheen**	A light, almost transparent layer of oil. Sometimes confused with windrows and natural sheen resulting from biological processes.
2	**Silver sheen**	A slightly thicker layer of oil that appears gray, silvery or shimmers.
3	**Rainbow sheen**	Sheen that reflects colors
4	**Brown oil** (heavy or dull sheen)	Water-in-oil emulsion. Thickness typically 0.1 to 1.0 mm. Can vary depending on wind and current conditions.
5	**Mousse**	Water-in-oil emulsion. Colors can range from orange or tan to dark brown.
6	**Black oil**	Sometimes with a latex texture. Can look like kelp and other natural phenomena.
7	**Windrows** (fingers, stringers, streamers)	Oil or sheen oriented in lines or streaks. Brown oil and mousse can be easily confused with algal scum collecting in convergence lines, algae patches, or kelp.
8	**Tar balls**	Oil weathered into a pliable ball up to 30 cm. Sheen may or may not be present.
9	**Tar mats**	Non-floating mats of oily debris (usually sediment and/or plant matter) found on beaches or just offshore in shallow water.
10	**Pancakes**	Isolated patches of mostly circular oil (size range a few centimeters to 100s of meters in diameter). Sheen may or may not be present.

Oil on the water

- Oil is best viewed with the sun behind the observer, flying at a 30-degree angle to the slick.
- Mid-morning or mid-afternoon viewing is generally best, avoiding midday glare off the water and the limited contrast encountered in early morning or early evening.
- Overall spill dimensions are generally best viewed from an altitude of 1000-2000 feet.
- Estimating oil coverage and color are best from an altitude of 200-300 feet or less.
- Oil surface slicks and plumes can appear different for many reasons including oil or product characteristics, sun angles, viewing angles, type of observation platform, weather, light conditions, sea state, and dispersion rate.
- Waves, kelp beds, natural organics, pollen, plankton blooms, cloud shadows, jellyfish and algae can all look like oil under certain conditions.
- Low-contrast conditions (*e.g.*, overcast, twilight, haze) make observations difficult.

Dispersant applications

- May have variable effectiveness where different oil concentrations (spill thicknesses) result in variable oil/dispersant ratios being applied.
- May cause herding, temporarily “pushing” the oil together and making the slick appear to shrink, or to disappear from the sea surface for a short time.
- May change the color of an emulsified slick by reducing water content and viscosity.
- May change the shape of the slick, due to the de-emulsification action of the dispersant.
- May modify the spreading rates of oils (treated slicks can cover larger areas).

Dispersed oil plumes

- May not form immediately after dispersant application, especially if the oil is emulsified or there is low mixing energy.
- May not form or be visible at all.
- May be masked by surface oil and sheen or hidden by poor water clarity.
- May be mistaken for other things such as suspended solids.
- Are often highly irregular in shape and concentration.
- Can range in appearance from brown to white or cloudy.

Dispersant effectiveness

- A visible cloud in the water column indicates the dispersant is working
- Differences in the appearance of treated and untreated slicks indicate dispersion is likely.
- Boat wakes may physically part oil, falsely indicating successful dispersion.

D.7 **Dispersant Observation Checklist**

To be completed by dispersant observers on aircraft and vessels before departure

Incident name: ____ Report number:_____

This report by: ________________________ Organization: ____________________ Date: ______ Time: ______

Observer name(s) and organizations: ____

____

Observation platform: Helicopter / aircraft / boat / other (specify): ____

Application platform: Helicopter / aircraft / boat / other (specify): ____

COMMUNICATIONS

	VHF	UHF	Other
Air to air:	____________	____________	____________
Air to vessel:	____________	____________	____________
Air to ground:	____________	____________	____________
Ground to vessel:	____________	____________	____________
Vessel to vessel:	____________	____________	____________

	Aircraft/personnel names	Call sign	ETD to spill	ETA at spill
Sprayer 1:	____________	____________	______	______
Sprayer 2:	____________	____________	______	______
Spotter:	____________	____________	______	______
Observer:	____________	____________	______	______
Command Center:	____________	____________	______	______

DISPERSANT

Name: ____________________ Dispersant : oil ratio: ______________________________

Application altitude (ft): ____________________ Dilution prior to application (if any): ____________________

Observation altitude (ft): ____________________ Application rate: ______________________________

Circle one: gallons/acre, gallons/km^2, liters/hectare

WEATHER ❑ Sunny ❑ Overcast ❑ Cloudy ❑ Rain ❑ Fog

(Circle units used)

Sea state: __________ Wind speed: _________ knots or mi/hr Air temp: ______ ºC/ºF

Wave height: __________ m/ft Wind direction: _________ ºtrue/ºmagnetic Sea temp: ______ ºC/ºF

Water depth: __________m/ft Current speed: _________ knots or mi/hr Salinity: ______ ppt

Visibility: __________nm Current direction: _______ ºtrue/ºmagnetic Tide: ______(flood/ebb/slack)

DISPERSANT OBSERVATION EQUIPMENT AND SAFETY CHECKLIST

Observation

- Basemaps, charts
- Clipboard, notebook, reporting forms, checklists
- Pens, pencils
- GPS, spare batteries
- Job aids for visual observation
- Camera, spare film
- Video camera, spare batteries
- Binoculars

Personal safety

- Lifejacket (and exposure suit if required)
- Survival equipments (*e.g.*, flares, locator beacon)

Safety brief

- Safety brief with pilot/skipper
- Purpose of mission
- Operational constraints
  - Area orientation, observation plan
- Trip duration
- Landing or mooring sites
- Radio frequencies and reporting schedule
- Safety features (*e.g.*, emergency locator beacon, fire extinguishers, first aid kit, radios)
- Emergency exit procedures
- Gear deployment (*e.g.*, current drogue, dye)

From Cawthron, 2000

D.8 **Dispersant Observations Report Form**

For recording dispersant observations from aircraft and vessels

Incident name: ____ Report number:_____

This report by: ______________________ Organization: ___________________ Date: ______ Time: ______

Application start time: ________________ (military time) Viewing difficulties (if any): ________________________

Application finish time: ________________ (military time) ____

VISUAL APPEARANCE OF SLICK (use standard definitions and visual guides of oil on water)

Before application	Immediately after application	20 minutes after application
______________________________	______________________________	______________________________
______________________________	______________________________	______________________________
______________________________	______________________________	______________________________
______________________________	______________________________	______________________________
______________________________	______________________________	______________________________
______________________________	______________________________	______________________________
Film roll #: ____________________	Film roll #: _____________________	Film roll #: __________________
Photo #: _______________________	Photo #: ________________________	Photo #: _____________________

Dispersion cloud observed? ❑ Yes ❑ No

Time taken for cloud to form: __________ minutes

Did oil re-appear (re-coalesce)? ❑ Yes ❑ No

Time taken to reappear: __________ minutes

% of slick treated: _________

% overspray: _________

Estimated % efficiency: _________

Describe any variation in effectiveness across slick:

Describe differences between treated and untreated areas:

Describe any biota present and any effects observed:

General comments/problems encountered:

Recommendations for future applications:

Start position

Latitude: __________________________ north

Longitude: ________________________ west

Distance from shore: ________________ km or miles

Finish position

Latitude: __________________________north

Longitude: ________________________ west

Distance from shore: ________________ km or miles

From Cawthron, 2000

D.9 Wildlife Aerial Survey Form

Incident name: ____ Survey #: ____ Flight # ____
Date: ___________ Survey page ____ of ____

Survey Crew: ____ Survey Equipment:________________________________
____ ________________________________
____ ________________________________
____ ________________________________

Flight information:
Aircraft type: __________________________________
Start flight local time: ___________
End survey local time: ___________
End survey local time: ___________
End flight local time: ___________
Survey altitude range (ft): ___________

Physical conditions:
Wind (kts): _________ from direction: _____________
Cloud cover (%): _________ Seastate (wave height): ____ ft

Overall sighting conditions:
☐ Excellent ☐ Very good ☐ Good
☐ Fair ☐ Poor

Sighting #	**Sighting specifics**			**General location**
	Number of animals:	Lat:	Taxa:	
	Local time:	Long:	Species/ancillary ID info:	
	Current altitude (ft):			
Sighting	Number of animals:	Lat:	Taxa:	
	Local time:	Long:	Species/ancillary ID info:	
	Current altitude (ft):			
Sighting	Number of animals:	Lat:	Taxa:	
	Local time:	Long:	Species/ancillary ID info:	
	Current altitude (ft):			
Sighting	Number of animals:	Lat:	Taxa:	
	Local time:	Long:	Species/ancillary ID info:	
	Current altitude (ft):			
Sighting	Number of animals:	Lat:	Taxa:	
	Local time:	Long:	Species/ancillary ID info:	
	Current altitude (ft):			
Sighting	Number of animals:	Lat:	Taxa:	
	Local time:	Long:	Species/ancillary ID info:	
	Current altitude (ft):			
Sighting	Number of animals:	Lat:	Taxa:	
	Local time:	Long:	Species/ancillary ID info:	
	Current altitude (ft):			
Sighting	Number of animals:	Lat:	Taxa:	
	Local time:	Long:	Species/ancillary ID info:	
	Current altitude (ft):			
Sighting	Number of animals:	Lat:	Taxa:	
	Local time:	Long:	Species/ancillary ID info:	
	Current altitude (ft):			
Sighting	Number of animals:	Lat:	Taxa:	
	Local time:	Long:	Species/ancillary ID info:	
	Current altitude (ft):			
	Current altitude (ft):			
Comments:				

Wildlife Aerial Survey Form, continued

Incident name: ____ Survey #: ____ Flight # ____
Date: __________ Survey page ____ of ____

Sighting #	**Sighting specifics**			**General location**
	Number of animals:	Lat:	Taxa:	
	Local time:	Long:	Species/ancillary ID info:	
	Current altitude (ft):			
Sighting	Number of animals:	Lat:	Taxa:	
	Local time:	Long:	Species/ancillary ID info:	
	Current altitude (ft):			
Sighting	Number of animals:	Lat:	Taxa:	
	Local time:	Long:	Species/ancillary ID info:	
	Current altitude (ft):			
Sighting	Number of animals:	Lat:	Taxa:	
	Local time:	Long:	Species/ancillary ID info:	
	Current altitude (ft):			
Sighting	Number of animals:	Lat:	Taxa:	
	Local time:	Long:	Species/ancillary ID info:	
	Current altitude (ft):			
Sighting	Number of animals:	Lat:	Taxa:	
	Local time:	Long:	Species/ancillary ID info:	
	Current altitude (ft):			
Sighting	Number of animals:	Lat:	Taxa:	
	Local time:	Long:	Species/ancillary ID info:	
	Current altitude (ft):			
Sighting	Number of animals:	Lat:	Taxa:	
	Local time:	Long:	Species/ancillary ID info:	
	Current altitude (ft):			
Sighting	Number of animals:	Lat:	Taxa:	
	Local time:	Long:	Species/ancillary ID info:	
	Current altitude (ft):			
Sighting	Number of animals:	Lat:	Taxa:	
	Local time:	Long:	Species/ancillary ID info:	
	Current altitude (ft):			
Sighting	Number of animals:	Lat:	Taxa:	
	Local time:	Long:	Species/ancillary ID info:	
	Current altitude (ft):			
Sighting	Number of animals:	Lat:	Taxa:	
	Local time:	Long:	Species/ancillary ID info:	
	Current altitude (ft):			
Sighting	Number of animals:	Lat:	Taxa:	
	Local time:	Long:	Species/ancillary ID info:	
	Current altitude (ft):			
Sighting	Number of animals:	Lat:	Taxa:	
	Local time:	Long:	Species/ancillary ID info:	
	Current altitude (ft):			
Comments:				